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PROGRAM

OF THE

CHICAGO MEETING

NOVEMBER 26-27, 1926

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CHICAGO MEETING NOVEMBER 26-27, 1926

The 141st regular meeting of the American Physical Society will be held in Chicago, Illinois, at the Ryerson Physical Laboratory on Friday and Saturday, November 26 and 27, 1926. The first session will be at 10 o'clock on Friday morning.

On Saturday morning two sessions will be held, in Rooms 32 and 33.

Titles and abstracts of the papers to be presented are given in the following pages. These abstracts have not been corrected by the authors. After correction, they will be published in an early number of the Physical Review. Authors should send corrections to the Editor of the Physical Review at Minneapolis, Minn.

Dinner. On Friday evening there will be a dinner for members of the Society and their friends at the Quadrangle Club. The price per person will be $1.50. Tickets must be purchased before 2 o'clock Friday afternoon.

CALENDAR

Friday morning at 10 o'clock. Room 32: Papers 1-10.
Friday afternoon at 2 o'clock. Room 32: Papers 11-20.
Saturday morning at 10 o'clock. Room 32: Papers 21-31.
Room 33: Papers 32-42.
Saturday afternoon at 2 o'clock. Room 32: Papers 43-54.

The supplementary papers beginning with No. 55 may be called for at the end of any one of the sessions held in Room 32.

Philadelphia Meeting. The 142nd regular meeting of the American Physical Society will be held in Philadelphia, December 28-31, 1926, in affiliation with Section B—Physics—of The American Association for the Advancement of Science. Members intending to present papers at this

meeting should have titles and abstracts (not exceeding 200 words) *ready for publication,* in the hands of the Secretary *not later than Wednesday, December 1.*

Other meetings for the current season are as follows:

143. February 26, 1927. New York.
144. Pacific Coast Section—Place not yet determined.
145. April 22-23, 1927. Washington.
146. Pacific Coast Section—Place not yet determined.

HAROLD W. WEBB, *Secretary,*
Columbia University, New York City.

PROGRAM

FRIDAY MORNING AT 10 O'CLOCK

Room 32

1. A preliminary report on the study of the emission spectra and surface tension alterations in experimental animal tumors. DONALD C. A. BUTTS, THOMAS E. HUFF, and FREDERICK PALMER, JR., Hahnemann Medical College, Philadelphia, Pa.—In view of the fact that analytical chemical methods of comparing normal and pathologic tissue have offered little vital information as to the obscure alterations in pathologic cell change, and to further substantiate findings of one of the writers, the authors have studied the physical, chemical, and physical-chemical nature of experimental animal tumors, with interesting results. Although the results do not as yet warrant a conclusive report, several findings are of physical interest, and promise to materially advance our knowledge of cancer causation and to open up a promising field for a scientific method of attack.

2. A new instrument for measuring surface tension. F. E. POINDEXTER, University of Florida.—The downward pull on the stem of a hydrometer due to the surface tension of the liquid is used to measure this tension. The liquid wets both the inside and outside of the hydrometer stem, the sensitivity of the instrument depending, therefore, upon the wall thickness of the projecting stem and the density of the liquid, i.e. $T=\frac{1}{2}\rho S(r_2-r_1)g$, where T=surface tension, ρ=density of the liquid, S=the length of the portion of the stem submerged by the pull of the surface tension, r_1 and r_2 are the inside and outside radii of the stem respectively, and g=acceleration of gravity. The (r_2-r_1) of the one used was .040 cm and $S=3.57$ cm, giving the surface tension of water to be 69.97 dynes per cm at 27.5°C in good agreement with the value of 69.50 found by Ramsey and Shields by the capillary tube method.

3. A theory of the mechanism of crystal growth. WHEELER P. DAVEY, Pennsylvania State College.—There is considerable evidence that crystallization does not proceed uniformly along a plane surface but, instead, proceeds along a sort of three-dimensional lattice-work which is later filled in with crystalline material. For instance if a supersaturated solution of photographic hypo is crystallized, the three-dimensional lattice-work may be seen, simulating the crystal axes, with hypo solution in the interstices. This suggests that all "single crystals" grow in somewhat similar fashion. Evidence of such a lattice-work may be seen inside the contraction cavities of large-grain pure copper crystallized in dry oxygen-free H_2. The ends of a similar lattice-work were found at the end of a large single crystal of copper from which the molten metal had been suddenly removed. Evidences of the lattice-work were also found on the surface of copper cast in H_2 and in the surface skin surrounding single crystal copper. This means that the material which solidifies later in the meshes of the lattice-work is under tension. Thus all crystals are produced in a state of strain. This accounts satisfactorily for etching pits, the "solution cavities" of Honess, dendrite formation and other metallographic phenomena as well as the customary imperfections in crystal structure noted in x-ray work.

4. Solid solutions of chromium and nickel and of iron and nickel. F. C. BLAKE, JAMES LORD and A. E. FOCKE, Ohio State University.—Curves are given showing that chromium goes into the nickel lattice up to 63 percent chromium by weight the maximum amount of distortion being 2.8 percent. From 63 percent to 100 percent chromium by

weight the nickel is in the face-centered chromium lattice, but this lattice being metastable at ordinary temperatures most of the chromium separates out as body-centered chromium. In the case of iron and nickel the iron distorts the nickel lattice up to 74 percent iron by weight, after which the nickel is in the face-centered iron lattice up to 100 percent iron by weight; but face-centered iron is stable only at high temperatures so most of the iron separates out at room temperature. In both cases miscibility is complete but there is overlapping between the regions of distorted face-centered nickel-chromium (or nickel-iron) and body-centered nickel-chromium (or nickel-iron). On account of the small difference in lattice between isomorphs of chromium, nickel and iron, a degree of precision higher than that now in use must be attained before the methods of x-ray analysis can determine whether the phase that separates out contains both metals in the body-centered state.

5. Piezoelectricity of crystal quartz. L. H. DAWSON, Naval Research Laboratory, Washington, D. C. (Introduced by E. O. Hulbert.)—Measurements with a quadrant electrometer of the piezoelectric charge in optically perfect crystal quartz have shown that the different specimens of quartz may produce charges of different magnitude. The piezoelectric charge appeared to be an integral effect over the surface since an exploration of the surface by an approximation to a point contact showed that charges varying in magnitude and sign may be produced on adjacent portions of the surface. The piezoelectric charge increased as the temperature was raised from room temperature to 60°C and decreased thereafter to 576°C where it disappears. The cooling curves show a lag. A relation between the pyro- and piezoelectric effects is pointed out. The facts established appear to be in accord with the theories of the imperfections of crystals and to agree with the views of Bragg and Gibbs in regard to the mechanism of the production of pyro- and piezoelectricity. The piezoelectric charges on surfaces variously oriented with respect to the optic axis showed a characteristic distribution hitherto unsuspected and not explainable by simple theory. This characteristic distribution lead to an accurate method for determining the direction of the electric axes of quartz.

6. An electronic theory of passivity. WILLIAM D. LANSING, University of Illinois. (Introduced by J. Kunz.)—Iron occupies a unique position in the middle of the first long period of the periodic table. Under normal conditions the electrons are probably distributed among the energy levels as 2,8,14,2. Under strong oxidizing conditions this may become 2,8,8,8, a structure analgous to krypton, and thus become passive, and non-magnetic as well. A method was developed for producing thin films of iron by cathode sputtering. These films were found to be passive. The work of Ingersoll and DeVinney on nickel would lead us to believe that these films were non-magnetic also, but our magnetic measurements are not yet complete. The electrode potential of ordinary iron in 0.5 molar FeSO was found to be +0.365 volts with respect to the hydrogen electrode, while passive iron in the same solution had an electrode potential of −0.508 volts. Thermodynamically, passive iron is the more stable, with a free energy change of 35700 cal. The electrode potential of sputtered iron in this solution ranged from 0.035 v. to −0.065 v., becoming more noble with time. This is explained by the supposition that the film is still too thick to be passive and non-magnetic all the way through.

7. A new electrophoretic mobility formula. MELVIN MOONEY, National Research Fellow, University of Chicago.—According to current theories of electrophoresis, the mobility of a particle should be independent of its size. However, the author has shown experimentally that with oil drops immersed in water there is a definite variation in mobility with the diameter of the drop. Therefore a new mobility formula has been developed, applicable to a rigid sphere in water containing a di-ionic electrolyte. The new theory takes into account the effect of ionic diffusion, and also the motion of the

water, on the charge distribution in the electric double layer. The mobility formula is obtained in the form of an asymptotic power series, of which only the first two terms have been calculated. However, these are sufficient to give a theoretical value for the slope when mobility is plotted against $1/D$, D being the diameter of the sphere. This formula has been tested with experimental results obtained with oil drops in solutions of various electrolytes at concentrations of 10^{-1} to 10^{-5} normality. At .01 normal or higher concentrations the theory definitely fails. At lower concentrations there is rough agreement between theory and experiment. More precise mobility measurements are necessary for a more decisive test of the theory at low concentrations.

8. A determination of the dielectric constant of air by a discharge method. A. P. CARMAN and K. H. HUBBARD, University of Illinois.—Two air condenser systems, one containing the test condenser and the other the balancing condenser, are charged to equal opposite potentials and the opposite charges are mixed and discharged through a galvanometer. The two condenser systems are adjusted until the galvanometer deflection is zero. A special form of rotating commutator was devised for which the contact resistances are small and uniform. This commutator has three pairs of make and break contacts, two for charging and discharging the two condensers, and one pair connected so that a single battery is used to charge both condensers. The capacity of the test condenser is obtained in terms of readings on a condenser which forms part of the balancing condenser system. The ratio of the capacities of the test condenser with a vacuum and with air for dielectric is then obtained. The calibration for the readings is made with the apparatus in place, by simple changes of connections. Possible errors from time lag, thermal expansions and deformations from pressure changes are discussed. The average of twelve separate measurements gives 1.000593 for the dielectric constant of air at 0°C and 760 mm Hg. pressure. The twelve separate readings agree in the fifth decimal place.

9. Shielded oscillator for Hertzian waves. J. TYKOCINSKI–TYKOCINER, University of Illinois.—A thermionic tube is mounted at each end inside a brass cylinder in contact with the cold electrode. The grids of the tubes are connected by means of an insulated rod placed concentrically in the cylinder. The electromagnetic field of the oscillator is confined to the space inside the cylinder, where a standing wave is produced along its axis with a potential node in a plane dividing the length of the cylinder in two equal parts. The variation of frequency is produced by condensers mounted inside the cylinder. The cylinder is closed at each end by means of rotating shielding caps which serve as dials for the tuning mechanism. Measurements on antennae or Lecher wires were made undisturbed by the stray field of the oscillator, by connecting them with two points of the rod, reached through holes made in the cylinder on both sides of the nodal plane. Standard 5 and 50 watt oscillating tubes were used. With an oscillator having a cylinder 100 cm long and 7.3 cm in diameter a frequency of 60×10^6 to 65×10^6 was produced. A shorter cylinder 66 cm long and 4.8 cm in diameter gave a frequency of 85×10^6.

10. A principle governing the distribution of current in systems of linear conductors. FRANK WENNER, Bureau of Standards.—Reference is made to practically all the laws, theorems, principles and procedures generally considered to pertain to the distribution of direct current in systems of linear conductors. Consideration is then given to a principle which has been used but little and seems to be practically unknown. This principle is applicable to systems of linear conductors in which the currents are proportional to the impressed electromotive forces and may be stated as follows: The current in any branch is that which would result if all impressed electromotive forces were replaced by a single impressed electromotive force located in the particular branch and equal to the drop in potential which originally would have appeared across a break had the branch been opened. A proof of this principle is given and some of the ad-

vantages to be gained by its use are illustrated by the solution of a graded series of problems. In some of these the currents are direct and constant, in others the currents are alternating, and in one the currents are transient.

FRIDAY AFTERNOON AT 2 O'CLOCK

Room 32

11. Fluorescence and chemiluminescence of cod-liver oil. JAY W. WOODROW and G. M. WISSINK, Iowa State College.—It has been shown that cod-liver oil will produce a developable image on a photographic emulsion and that this effect is much more pronounced if the oil has been previously exposed to ultra-violet light. At first this effect was thought to be due to an ultra-violet radiation but it was later explained as a direct chemical action analogous to the Russell Effect. We have found it possible to obtain a chemiluminescence of cod-liver oil by the oxidation of the heated vapor. The luminescence is of a bluish-green color but it is so faint that we have been unable as yet to obtain its spectrum. Kautsky and Neitzke have recently shown that the fluorescent and chemiluminescent spectra of all the substances they investigated have intensity maxima at the time wave-length. We have photographed the fluorescent spectrum of cod-liver oil illuminated by the light from a quartz mercury-vapor arc and find that it has a maximum intensity at a wave-length of about 5000A. The color of the fluorescent light as observed by the eye appears to be the same as that produced by chemiluminescence.

12. The magnetic susceptibility of rare earth metals. E. H. WILLIAMS, University of Illinois.—The magnetic susceptibilities of four rare earth metals, namely, cerium, lanthanum, praseodymium and yttrium, have been determined. In each case the value of the susceptibility depends on the intensity of the magnetic field, decreasing as the field is increased from 10 gauss to 4000 gauss. In this respect the magnetic susceptibility of the rare earth metals resembles very much the behavior of the permeability of iron. Owing to the low value of the susceptibilities, 20×10^{-6} to 50×10^{-6} dyne cm per gram, for the fields used, it is impossible with the methods available to fill in the gap for fields between 10 gauss and zero. This gap constitutes the most interesting part of the curve.

13. The magnetic moment of atomic hydrogen. T. E. PHIPPS and JOHN B. TAYLOR, University of Illinois. (Introduced by W. H. Rodebush.)—The magnetic moment of atomic hydrogen has been investigated by the atomic ray method introduced by Stern and Gerlach. Atomic hydrogen formed in a discharge tube by the method of R. W. Wood was first used. The ray was formed in a special all-glass slit system of three slits sealed to the discharge tube. The ray was detected by the reduction resulting on contact with a target coated with molybdenum trioxide. A sharply defined blue line against a white background was the result. In the magnetic field the ray was separated into two branching rays. There was also evidence of a central undeviated ray, which is believed to be due to molecular rather than atomic hydrogen. From a measurement of the deflection, the magnetic moment of the hydrogen atom was calculated to be one Bohr magneton, within the limits of experimental error. In addition, atomic hydrogen formed by the hot filament method of Langmuir was used. The increased velocity of the atoms in this case allowed less separation of the ray, but a deflection was distinctly recorded. Finally, the product formed on exposing a mixture of mercury vapor and hydrogen to ultra-violet light was investigated. This is believed by Cario and Franck, Taylor and others to be atomic hydrogen. Thus far attempts to form a ray which will reduce the target have been unsuccessful. The reasons for this are being investigated.

14. Spectroscopic interpretation of the magneton numbers in the iron group. A. SOMMERFELD, University of Munich, and O. LAPORTE, University of Michigan.—For the spectroscopic interpretation of the measured magneton numbers for the ions

of the first long period an average of the $j.g$-values for the different levels of the polyfold ground-term must be taken. This was not necessary for the paramagnetism of the rare earths (Hund) since the separations $\Delta\nu$ are so large that only the lowest level needs to be considered. The exact formula for the magneton number (in Weiss-units) becomes:

$$\mu_w = 4.97\ (\Sigma N_j\, j(j+1)g(j, l, s)\ )^{\frac{1}{2}}/(\Sigma\ N_j)^{\frac{1}{2}}:$$

j, l, s are the quantum numbers of the level in question and N_j the weight: $(2j+1)$ exp. $(-hc\Delta\nu/kT)$. The terms which are assumed to represent the normal state of the ions are computed according to the Stoner Periodic System using the rules given by Pauli and Hund. If the lowest term is single (i.e., of S type), the magnetic moments computed in the old fashion and those according to this formula must furnish the exact measured value—this is indeed the case for $Fe^{\cdots}$ and $Mn^{\cdot\cdot}$, the lowest term of which is ${}^6S$—whereas in general the observed values lie between the two curves drawn for $\Delta\nu = 0$ and $\Delta\nu = \infty$. The Boltzmann factor also causes a dependence of μ upon the temperature. The Heisenberg-Schroedinger quantum mechanics does not alter the above formula.

15. Resonance spectra in metallic vapours excited by the light in the mercury arc. J. C. McLennan, University of Toronto, and I. Walerstein, University of Chicago.—The fluorescence spectrum of iodine obtained by McLennan with iodine vapour excited by the light in the mercury arc, suggested an investigation into the effects of ultra-violet light on the vapours of other elements. Resonance spectra were obtained from the vapours of sulphur, selenium, tellurium, and bismuth at moderate temperatures by using a large quartz mercury lamp as source of excitation. The vapour of sulphur gave a set of bands extending over the range of the visible spectrum. Selenium at 325°C gave a resonance spectrum ranging from 2200A to 6500A while at 425°C it emitted a different spectrum consisting only of 9 very broad bands between 4178A and 4829A, and this latter spectrum itself disappeared at higher temperatures. The resonance spectrum of tellurium consisted of a set of regularly spaced bands in the visible region, and the relative intensities of the bands varied according to the pressure of the vapour. Bismuth emitted a band spectrum in the region 4400A to 4900A. It was found that the region of the mercury arc which excited the tellurium vapour to produce resonance radiation was between 2536A and 3655A.

16. Some laboratory observations bearing on the spectra of comets. Harvey B. Lemon, University of Chicago.—Among the most conspicuous bands in comet spectra are those of the Swan spectrum attributed in the past by some to a carbon molecule and by others to CH or $(CH)_2$. All spectra appearing in comets can be produced with a large excess of helium and low partial pressures of carbon compounds. If hydrogen also is present, revealed by the Balmer lines, the Swan spectrum is brilliantly developed in a Wood type tube, and this spectrum appears and fades simultaneously with the Balmer series. This is taken as direct evidence for the hydrocarbon origin of this spectrum, and also for the presence of hydrogen in comets. Sodium occasionally appears in cometary nuclei, always temporarily near perihelion. In Halley's comet Slipher found only D_2, and in Brooks' comet Wright found D_2 three times D_1 in intensity. Usual laboratory excitation gives $D_2 : D_1 = 10 : 7$. In a thermionic tube with CO at 10^{-5} cm or less and a trace of Na as impurity, the D lines appear when the filament is heated to its maximum temperature. Their relative intensity is $D_2 : D_1 = 5$ to $25 : 1$, and the similarity between their appearance and the conditions of excitation to that in comets becomes striking.

17. The spectra of comets. N. T. Bobrovnikoff, University of Chicago. (Introduced by Harvey B. Lemon.)—All bands and lines observed in the cometary spectra can be attributed to: (1) Carbon and its compounds (the first positive (Swan), and the third negative groups, CO^+, "high pressure" Fowler CO bands, C+H bands, line spectrum C^+; suspected:—Baldet-Johnson system and the Triplet system). (2) Nitrogen and its compounds (N neutral, line spectrum, N^{++}, and the first negative and third

positive groups, the violet and red groups of CN; uncertain: N^+). (3) Hydrogen, the continuous molecular spectrum and probably the secondary spectrum. These spectra can be obtained in the laboratory in an excess of inert gases and with a partial pressure of the emitter of the order $10^{-4}-10^{-5}$ cm. For their production no disruptive discharge is necessary. The excitation potentials of these spectra do not exceed 24 volts. In the occasional appearance of sodium D lines, near distance to the sun is the chief though not only factor. Neutral helium is suspected in comets. The radiation pressure formula of Schwarzchild cannot be applied to the case of comets' tails which are of a gaseous nature. Einstein's modification of Planck's radiation formula may be applied.

18. A compound interferometer for fine structure work. WILLIAM V. HOUSTON, National Research Fellow, California Institute of Technology.—The principal difficulty in the use of the Fabry-Perot interferometer to measure spectral fine structure is that when high resolution is used the successive orders usually overlap. This difficulty can be avoided by using two such interferometers in series. The dispersion of the interferometer is independent of the plate separation, while the distance between orders is inversely proportional to it. Thus an instrument with a small separation may be used as a preliminary filter to eliminate many of the orders in one of larger separation, without affecting the fine structure pattern. In this case the resolution is even greater than that due to the larger separation. To get the best results it is necessary to adjust the separations to the ratio of small whole numbers. This can be done by means of the fact, discovered by Perot and Fabry, that white light fringes appear when this condition is satisfied. The mathematical theory of this instrument has been worked out and an instrument is almost finished, which will be applied to the study of the Balmer lines and other fine structure problems. It promises to be especially valuable in the study of hyper-fine structure.

19. The effect of a variation from the condition for achromatism in lenses. T. TOWNSEND SMITH, University of Nebraska.—It is well known that two thin lenses in contact will form an achromatic pair, if the focal lengths of the two are in the ratio of the dispersive power of the glasses. The focal length of such a combination is a minimum for some wave-length (λ_1), which depends upon the ratio of the focal lengths and which is near 550mμ, if the dispersive power be specified in terms of lines C and F. There seem to be no criteria available for judging of the goodness of the color correction in its dependence upon λ_1. The present work is an attempt to get some information upon this question. With the aid of Hartmann's dispersion formula and on the assumption of a dense flint (Schott 0–103) diverging and a silicate crown (Schott 0–60) converging lens, the resultant brightness on the axis has been calculated for various values of the focal lengths and for various apertures, and from these values, graphically represented, an estimate may be made as to the goodness of the color correction in so far as it depends upon these variables.

20. Extreme ultra-violet spectra using large angles of incidence. J. BARTON HOAG, University of Chicago.—A vacuum spectrograph has been constructed using a concave speculum grating of 215.3 cms radius having 591 lines per mm. The familiar Rowland mounting is used except the slit is placed close to the grating making the angle of incidence approximately 80°. Using carbon and magnesium electrodes, spectra have been obtained from 220A to 1700A. The scale varies from 3.54A per mm at 1600A to 2.26A per mm at 550A in the first order. Preliminary measurements give an accuracy of .04A.

SATURDAY MORNING AT 10 O'CLOCK

Room 32

21. Note on the auroral green line 5577. DAVID A. KEYS, McGill University.—In view of the recent important work of McLennan, Vegard and others on the origin on the auroral green line 5577, the light emitted from the electrical discharge in mixtures of (1) helium and oxygen and (2) argon and oxygen was investigated with a Hilger quartz spectograph of D type by the writer while a guest of the Nela Research Laboratory at the kind invitation of Dr. W. E. Forsythe. In a mixture of oxygen and argon (argon pressure = 40 mm, oxygen pressure = 8 mm) contained in a pyrex tube 8 mm internal diameter made in H-form, the line 5577 appeared very strongly. Tungsten electrodes were used, the current was 80 milliamps/cm² and potential 800 volts from a transformer. The oxygen soon combined with the tungsten forming a bluish deposit on the glass walls after which no trace of the line appeared. This result confirms that of McLennan, Ireton and Thompson (Nature, Sept. 25, 1926) and is further evidence that the line is primarily due to oxygen. Some evidence of the line in a mixture of helium and oxygen was also found.

22. Spectrum of Cu II. A. G. SHENSTONE, Princeton University.—The theoretically lowest terms of Cu II are $^1S(d^{10})$ and ^3D, $^1D(d^9s)$. Approximate separations are predictable from Cu I. They should combine with (d^9p) ^3P, $^3D'$, ^3F, ^1P, $^1D'$, ^1F and these also with higher ^3D, $^1D(d^9, s)$. Such terms, except ^1S, have now been found, accounting for all strong Cu II lines down to λ1944. Terms are all inverted except ^3F which is partially sinverted. The three possible combinations of ^1S should be about λ1400 with separation of 5185 and 494 cm^{-1}. Other terms, probably from d^9d, have been found but not designated. Intensities are regular except for inter-system combinations. Zeeman patterns to λ1979 give excellent confirmation except for $^3D_3'$ and $^1F_3$ which apparently share their g-sum, irregularly. Calculation of limits indicate, contrary to theory, that $^3D_3$ and $^3D_2$ converge to one limit and $^3D_1$ and $^1D_2$ to another. The separations $^3D_3 - {}^3D_1$ for the two terms are identical with $^4eD_4 - {}^4eD_1$ of Cu I. Calculated ionization potential of Cu II is approximately 17.8 volts from $^3D_3$ and 1.8 volts higher from ^1S. Published analyses of spectra Ni I and Pd I contain ^3D, ^1D terms showing same peculiarities of separation and convergence as Cu II terms. Calculated I. P.'s are Ni I, 7.8 volts, Pd I, 8.5 volts.

23. The absorption spectrum of antimony vapor. R. V. ZUMSTEIN, National Research Fellow, University of Michigan.—Antimony vapor is polyatomic. By slowly admitting the vapor into a hot carbon tube at about 1400°C, the molecules of vapor were dissociated into atoms and the atomic absorption spectrum was studied. The experimental method was described in The Physical Review, May, 1926. The arc lines 2311.50, 2175.88, 2068.38 were strongly absorbed. 2023.86 and 2127.46 were also absorbed but with considerably less intensity. These results are in agreement with the analysis of the antimony arc spectrum by Ruark, Foote, Mohler and Chenault (B.S. Sc. Papers **19**, 479, (1924)). All of the five absorption lines come from the $3d_2$ state, which is without doubt the normal state of the atom. The absorption of λ2311.50 was previously observed by Narayan and Rao. (Phil. Mag. **50** 648, (1925).)

24. Band spectrum, continuous emission, and continuous absorption of fluorine gas. HENRY G. GALE and GEORGE S. MONK, University of Chicago.—The band spectrum, consisting of ten bands between 5100A and 7200A has been photographed by long exposures with a concave grating spectrograph of 2.64A per mm dispersion. Sufficient detail has been obtained for an analysis of two bands and to show the general structure of two others. The zero points of the bands are given by $\nu = 17438.8 + (1104.9n' - 2.9n'^2) - (1071.5n'' - 9.9n''^2)$, yielding frequencies $\nu_0 = 19637.0$, 18540.8, 17438.8, 16377.2,

15335.3, 14325.0; having vibrational quantum numbers $n'\,n''=2,0;\ 1,0;\ 0,0;\ 0,1;\ 0,2;\ 0,3$ respectively. Analysis of the bands at $\nu_0=17438.8$ and $\nu_0=16377.2$, having the same initial vibration frequency, and satisfying the combination $R(m)-P(m)$, gives $2B=3.8\pm0.4$, or, $J=14.5\times10^{-40}$. A peculiarity of these bands is the increasing fuzziness of the lines from band to band toward the red. For experimental reasons the emitter is believed to be the F_2 molecule. In spectrograms obtained using a spark discharge in fluorine two continuous emission bands are shown at approximately 2800A and 2600A. Spectrograms showing the absorption of fluorine have been obtained, using columns of the gas, at atmospheric pressure, as short as 7 cm and as long as 3 m. Continuous absorption occurs to the violet of 4100A. No line absorption spectra were obtained.

25. Excitation of arc spectrum of nitrogen. R. A. WOLFE and O. S. DUFFENDACK, University of Michigan.—The arc spectrum of nitrogen was excited in an interrupted low voltage arc in a mixture of helium and nitrogen. The nitrogen arc lines were very strong in a limited region whereas in other regions helium lines or nitrogen bands strongly predominated. The intensity of the nitrogen lines was such that the spectrum could be photographed on a contrast plate in two hours with a Hilger E 1 quartz spectrograph. This spectrograph with glass prism and lens was employed in the region 4000–7400A, where exposures of three hours sufficed. All but a few of the lines reported by Merton and Pilley were verified, and a considerable number of additional lines were found. A number of these agree with lines reported by Hardtke, not found by Merton and Pilley. Others of these fill vacant spaces in multiplets computed by Kiess for the quartet system. The strength of the nitrogen lines in this arc is undoubtedly due to a high degree of dissociation of the nitrogen by excited helium atoms present in large concentration. This is in accord with the theory of the low voltage arc and with K. T. Compton's explanation of the origin of the nitrogen arc lines in Merton and Pilley's discharge.

26. Intensity relations and electronic states in spectra of diatomic molecules. ROBERT S. MULLIKEN, Washington Square College, New York University.—The correspondence principle predicts definite intensity relations for P, Q, and R band lines in molecules having a rotational energy term $F=B(j^2-\sigma^2)+\ldots$, provided σ is an electronic quantum number corresponding to a precession about the internuclear axis (along which the angular momentum $\sigma h/2\pi$ is directed). Hönl and London have given equations, obtained with the help of the summation rule, for the three possible cases $\Delta\sigma=0,\ \pm1$. Let I represent intensity. Then for low values of j (rotational quantum number), the theory predicts $I_R>I_P$ (especially when σ is large) if σ decreases during emission, but $I_P>I_R$ if σ increases, and $I_q=I_P+I_R$, approximately, in both cases. For $\Delta\sigma=0$, the prediction is $I_P=I_R$, with I_q small (vanishing with σ) and falling with increasing j. Various band spectra have recently been interpreted by the writer as corresponding to electronic transitions ${}^1S\rightarrow{}^1S$ (CuH type), ${}^1P\rightarrow{}^1S$ (AlH, He_2 "series" bands), ${}^1D\rightarrow{}^1P$ (He_2 $\lambda5733$), ${}^1S\rightarrow{}^1P$ (He_2 $\lambda4546$ and 6400, CO Angstrom), with $\sigma=0$ for ${}^1S$, $\sigma=1$ for ${}^1P$, and $\sigma=2$ for ${}^1D$ states. These interpretations, and the proviso mentioned above as to the nature of σ, are now found completely confirmed in a comparison of available intensity data with the predictions of the theory.

27. The beta bands of nitric oxide. FRANCIS A. JENKINS, HENRY A. BARTON, and ROBERT S. MULLIKEN, Harvard University and Washington Square College, New York University.—The NOβ bands have been photographed, using an active nitrogen source, in the second order of the 21-foot concave grating at Harvard University. Each band consists of two sub-bands H and L each composed of a P and an R branch of nearly equal intensity, and a very weak Q branch (much weaker in H than in L) whose intensity falls steadily from the first line. The otherwise continuous P–R series shows two missing lines in the H sub-band, four in the L sub-band. The quantum analysis discloses two distinct initial (H' and L') and two distinct final (H'' and L'') sets of rotational levels, all with integral quantum numbers. All the above relations are

accounted for if the rotational terms are of the form $B(j^2-\sigma^2)+\ldots$, with $\sigma=\frac{1}{2}$ for the H' and H'' levels, $\sigma=1\frac{1}{2}$ for the L' and L'' levels, and $j=\sigma+\frac{1}{2}, \sigma+1\frac{1}{2}, \sigma+2\frac{1}{2}, \ldots$; the intensities agree closely with those calculated from the appropriate Hönl and London equations (cf. preceding abstract). The bands evidently correspond to $^2P\rightarrow{}^2P$ electronic transition. Preliminary values for the internuclear distance are $r_{H'}=1.44$, $r_{L'}=1.40$, $r_{H''}=1.16$, $r_{L''}=1.14$, all times 10^{-8} cm.; the r'' values refer to the normal state of NO.

28. Carbon monoxide band excitation potentials. ANN B. HEPBURN. University of Chicago.—By using a hot filament three element tube, in which the grid and filament were so arranged as to enclose a field free space about one mm from the filament, it was possible to make visual and photographic determinations of the excitation potentials of the 0,0 bands of the Angstrom, Comet Tail, First Negative Deslandres, and Baldet-Johnson band systems of CO. A residual pressure of mercury vapor from the condensation pumps was present in the tube and was used as a means of correcting for the P.D. across the filament and contact e.m.f.'s in the tube. λ2537 (4.9 volts) was used with the photographic observations and λ5461 (7.7 volts) was used for the work in the visible. Computations made by Birge indicate that λλ4511, 4880, 2190, 3794 should be produced by electrons having a minimum velocity corresponding to 10.7, 16.7, 19.8, 19.8 volts respectively. The experiments performed confirm the computations within the limit of experimental error, namely, ±.1 volt.

29. An investigation of some hydrocarbon bands. FRANK C. MCDONALD, University of Chicago. (Introduced by Harvey B. Lemon.)—Two new bands, λ2264, λ2367, have been analyzed according to the quantum theory. These bands were found when methane was introduced into a Wood tube and excited by a condensed discharge. The same bands appeared when acetylene was mixed with helium and excited by a transformer discharge. Many more lines were observed on the methane plates than on the acetylene plates. These bands have been arranged in P and R branches with a single missing line. They have been shown to belong to the same system with a common initial state. The possibility of a CH ion as the carrier is considered. New plates with high dispersion of a band, λ3143, originally reported by Fortrat, have been obtained. However, the structure of the band on these plates seemed to differ in several respects from that given by Fortrat. This band and a subsidiary band, λ3157, were found when methane was allowed to flow through a Wood tube and subjected to a condensed discharge. A more complete analysis has been made than that previously given.

30. The titanium bands. R. T. BIRGE and A. CHRISTY, University of California.—Using chiefly previously published data, we have been able to arrange 18 of the well-known titanium bands (eight with a measurable second head) in one system, and to assign vibrational quantum numbers. The heads are given by

$$\nu=\frac{19{,}350.0}{19{,}340.0}+(833.1n'-4.5n'^2)-(1003.5n''-3.5n''^2-\ldots.)$$

with an average residual of one cm^{-1}. The electronic energy change and the frequencies of vibration show a close correlation with the corresponding values for the aluminum bands which are now definitely known to be due to AlO. The distribution of intensity among both the vibrational and the rotational states is closely the same for the two molecules. A rough preliminary estimate of the moment of inertia shows a similar correlation. All these facts point very strongly to the conclusion that these titanium bands are due to TiO, and not to TiO_2, and this fact should be considered in astrophysical work on these bands, which form the dominant feature of M-type stars. Fine structure analysis of the 0–0, 1–0, and 0–1 bands, using new spectrograms taken especially for us by Dr. King, is now in progress.

31. The fine structure of three infra-red absorption bands of ammonia. G. A. STINCHCOMB and E. F. BARKER, University of Michigan.—Using a grating spectrometer with a rock salt fore-prism, the fine structure of the 1.98μ, 2.2μ and 3.0μ bands of ammonia was determined. The 3.0μ band has been previously resolved by B. J. Spence. This work checks the shape of the curve and the frequency differences, but differs somewhat in the values assigned to the wave-lengths, and furnishes a little more detail. The 1.98μ band consists of about 30 lines spaced with fair regularity throughout the entire band. Its center is marked neither by an absent line, nor by a single zero branch of great intensity like that at 3.0μ. The frequency difference between adjacent lines approximates 10.0 cm^{-1}. The 2.2μ band is extremely irregular making the location of the lines somewhat uncertain and yielding no obviously characteristic frequency difference. Here also no zero branch is apparent. While an accurate determination of the percentage of absorption was not considered of first importance, the growing interest in this phase of the problem has led us to employ unusual care, and it is believed that the percentage values assigned to the lines are fairly accurate.

SATURDAY MORNING AT 10 O'CLOCK

Room 33

32. On the theory of heats of fusion. N. RASHEVSKY, Westinghouse Research Laboratory, East Pittsburgh.—Plotting the potential energy ϕ of an aggregation of atoms against the atomic distance δ, we obtain a curve, having a minimum at $\delta=\delta_0$, (δ_0 = space-lattic econstant at absolute zero) and tending assymptotically to zero for $\delta=\infty$. At these two points we have $d\phi/d\delta=0$. Between these points there is a point δ_1, where $d^2\phi/d\delta^2=0$. As long as $\delta<\delta_1$, the deformation of the body causes a force to appear, which tends to restore the initial state, and which increases with increasing deformation. For $\delta>\delta_1$ the restoring force diminishes with increasing deformation. Hence there can be no question even about an approximate behaviour of the body as of an elastic one. This leads to the assumption, that when due to thermal agitation, the space-lattice constant reaches the value δ_1, the body becomes liquid. The amount of work, necessary to increase δ from δ_0 to δ_1 is thus interpreted as the total heat of fusion. Using for ϕ the expression $\phi=A/\delta^3-B/\delta^n$, and calculating A, B, and n from the compressibility and the thermoelastic constants according to Gruneisen, we may calculate with our assumption the heats of fusion. The values thus calculated for seven metals are in pretty good agreement with the experimental ones.

33. Theory of the specific heat of methane. JAKOB KUNZ, University of Illinois.—D. M. Dennison has recently given an analysis of the oscillations of methane based on the infra-red absorption bands. The results of this analysis and the quantum theory of radiation are used for the theoretical determination of the specific heat of methane. It is found in general that the theoretical values are a little higher than the experimental values (as function of the temperature).

34. The activity of monovalent ions. HANS MUELLER, Mass. Institute of Technology.—Debye's theory of strong electrolytes breaks down when applied to small ions because the approximation $\sinh\phi=\phi$ ($\phi=\epsilon\psi/KT$) is no longer justified. In this paper the differential equation $\Delta\phi=\sinh\phi$ is solved by extending analytically by an integration by steps Debye's solution $\phi=K\,e^{-r}/r$, correct for small values of ϕ. The activity-coefficients f are easily calculated with the following relation: $-kT\log f$ is the difference in the work to charge one ion in pure water and to charge it in an electrolyte with the concentration c in which all other ions already have their full charge. For small ions this calculation gives $f(c)$ curves which are below Debye's limiting curve for $a=0$. The

curves almost coincide with those calculated by Bjerrum (Danske Videnskabernes Selskab. **8,** 9, (1926)) assuming associated ions.

Concentration (mole/liter)	$-\log f(a=10^8$ cm)	Bjerrum's values
1	4.457	0.463
0.5	0.360	0.366
0.2	0.258	0.255
0.1	0.191	0.188
0.05	0.140	0.133
0.02	0.089	0.085

Hence Debye's theory fits the experimental results also for small ions without assuming partial association.

35. Optimum conditions for music in rooms. F. R. WATSON, University of Illinois.—Musicians prefer rooms for playing that are reverberant, while listeners are better pleased with deadened rooms. A series of experiments was conducted to adjust these apparently contradictory conditions. After investigating a number of rooms of widely different volumes that varied in reverberant qualities, a final experiment gave the solution. A room adjusted for "perfect" conditions was found unsatisfactory for both playing and listening, but on transferring the absorbing material from the end of the room occupied by the players to the end used for listening, the conditions were regarded as very acceptable both for playing and listening. This experiment indicates the desirable conditions for concert halls, studios, broad-casting rooms, etc., and suggests suitable arrangements for various acoustic experiments.

36. The theory of the Herschel-Quincke tube. G. W. STEWART, University of Iowa.—The well-known explanation of the Herschel-Quincke interference tube is that there is elimination of the transmitted wave when the difference in path in the two branches is an odd number of half wave-lengths. (This is a sound conducting tube branching into two parts of different lengths and reuniting, having a constant total area of cross-section at these two junctions.) This theory is incomplete. The ratio of the transmitted to the incident acoustic energy is
$16\ \sin^2(\alpha_2+\alpha_3)/2\times\cos^2(\alpha_2-\alpha_3)/2\times\{[1-2\ \cos(\alpha_2+\alpha_3)+\cos(\alpha_2-\alpha_3)]^2+4\ \sin^2(\alpha_2+\alpha_3)\}^{-1}$
where α_2 and α_3 are the phase changes over the two branches of the tube. This ratio is zero not only when $\alpha_2-\alpha_3=(2n+1)\pi$ as stated above, but also when $\alpha_2+\alpha_3=2n_1\pi$, provided $(\alpha_2-\alpha_3)\neq 2n_2\pi$, n_1 and n_2 being independent integers. The result is a great increase in interference frequencies. This theory is verified by experiment.

37. New measurements upon the light-sensitiveness of crystalline selenium. A. M. MACMAHON, University of Chicago.—A study is being made of the electrical conductivity of the element selenium, in crystalline form, with the purpose of expressing the light-sensitive property quantitatively in terms of reliable standards. As a preliminary report a three-parameter family of curves, showing the change in the electric current through a single, well-tested specimen as a function of the time, when the intensity and wave-length of the incident light and the applied potential difference are separately varied, is presented. These experimental results, relating the current, i, with the time of illumination, t, may all be fitted with surprising accuracy by a mathematical expression of the form,

$$i-i_0=A(1-\epsilon^{-at})+B(1-\epsilon^{-bt})$$

(Cf. Brown, Phys. Rev. **33,** 1, (1911).) The numerical values of the constants A, a, B and b are deduced and plotted as functions of the parameters named above. The extension of these data should be fruitful in the development of a more adequate theory than exists at the present time for these phenomena.

38. The x-ray L absorption edges of the elements Sn to Ru inclusive. GEO. D. VAN DYKE and GEO. A. LINDSAY, University of Michigan.—The L absorption edges for the elements Sn (50), In (49), Cd (48), Ag (47), Pd (46), Rh (45), and Ru (44) have been photographed with the use of a Seigbahn vacuum spectrograph. Calcite was used as a reflecting crystal. The absorbing screens for Sn, In, Cd, and Pd were rolled from the pure metal. The Ag absorption occurred in the film on the photographic plate. Rh and Ru were pulverized, mixed with collodion, and allowed to spread out in thin films. Since it has been found that the wave-length of the critical x-ray absorption limit depends upon the chemical combination of the element, and in many cases is accompanied by a series of absorption "lines" or fine structure on the short wave-length side of the principal edge, an investigation carried on with the pure element should yield energy values more characteristic of the substance than those obtained from compounds. A single white line on some of the plates is the only evidence of fine structure. Values of ν/R are calculated and compared with Coster's values for the same elements in compounds.

39. The intensity of reflection of x-rays by crystals and the Compton effect. G. E. M. JAUNCEY, Washington University.—In a recent paper by Bragg, Darwin and James (Phil. Mag. **1**, 897, (1926)) a formula is given for the case of an ideally imperfect crystal, corrections being made for extinction and temperature. At high orders of reflection the experimental intensity becomes much less than the formula demands. It is suggested that a further correction factor is introduced by the Compton effect, it being supposed that only those electrons which are in orbital positions U such as to scatter unmodified rays take part in the crystalline reflection of x-rays. Jauncey's theory of the unmodified line gives the ratio of the numbers of electrons in the U and M positions (Phys. Rev. **25**, 314, (1925)) so that a correction factor may be determined. Quoting from Bragg, Darwin and James' paper for rhodium Kα x-rays reflected from rocksalt at $\theta=30°$, their formula gives an intensity of 4.28, while the experimental value is 1.5. The correction factor on my theory due to the Compton effect at $\theta=30°$ ($2\theta=60°$) for rocksalt is 0.22 so that the expected value should be $4.28\times0.22=0.94$. As this number is the result of three approximate corrections the agreement is as good as could be expected.

40. The synthesis and disintegration of atoms as shown by an application of the Wilson cloud-track method. WILLIAM D. HARKINS and H. A. SHADDUCK.—In 1923, Harkins and Ryan (J. Am. Chem. Soc. **45**, 2096) developed and applied on a large scale a modification of the Wilson Cloud-Track Method which was capable of indicating the most important features of the mechanism of the disintegration of a light atom under bombardment. By the use of their procedure both Blackett (Proc. Roy. Soc. **107**, 349 (1925)) and the writers have obtained photographs which show that a fast α-particle may unite with a nitrogen nucleus on impact, and that a hydrogen nucleus is released. In 265,000 α-tracks of 8.6 cm range we have thus far found two disintegrations. In one of these the track of the H-particle is at an angle of 118° with that of the α-particle, and the range of the proton is 19.6 cm. That a proton is actually emitted is shown by the fact that kinetic energy is not conserved and the heavy nucleus gains 11 % of the kinetic energy from the α-particle. Also the track of the proton is only one-tenth as bright as the other tracks, and its visible portion is three times longer than is possible for any heavier particle.

41. Refraction of x-rays by method of total reflection. RICHARD L. DOAN, University of Chicago.—This is a continuation of the work described in a paper presented at the last Washington meeting of the Physical Society. Highly reflecting metallic surfaces of Ag, Cu, Au, Ni, and Fe, prepared by sputtering in vacuum onto an optical glass surface, were used as mirrors for the reflection of monochromatic x-rays obtained from copper and molybdenum water-cooled Coolidge tubes. Indices of refraction, as calculated from critical angle measurements, agree in general with theoretical values

as given by the Drude-Lorentz dispersion formula, although two exceptions have been noted. The refraction of the line CuKα_1 in Cu is particularly interesting because of the pronounced resonance effect due to the K-electrons. The theoretical value of the index of refraction calculated on the assumption of two K-electrons differs by about 20 per cent from the values obtained on the assumption of one or three electrons but agrees with the experimental determination to within two per cent. The expected departure from theory when an absorption limit is approached too closely has been observed in the cases of CuKβ refracted in Cu and CuKα_1 in Ni. The refraction of CuKα_1 in gold involves an effect due to the L-electrons and a theoretical calculation made on the basis of Stoner's assumed distribution of these electrons gives a value which agrees fairly well with experiment.

42. M series x-ray absorption spectra of osmium, iridium, and platinum. R. A. ROGERS, University of Iowa.—Using a metal x-ray tube and vacuum spectrometer of the Siegbahn type, the absorption spectra have been investigated from 3.5A to 7A. Spectrograms have been obtained showing five discontinuities for osmium at 6.194A (M_1), 5.975A (M_2), 5.027A (M_3), 4.412A (M_4), and 4.037A (M_5); four for iridium at 5.961A (M_1), 5.754A (M_2), 4.851A (M_3), and 4.270A (M_4); four for platinum at 5.736A (M_1), 5.541A (M_2), 4.674A (M_3), and 3.738A (M_5). Discontinuities corresponding to an M_5 level for iridium and an M_4 level for platinum were not obtained. The first two discontinuities, corresponding to M_1 and M_2, for each element are displaced toward shorter wave-lengths by more than 0.1A from the positions predicted, from theoretical computations, by Sommerfeld and Bohr and Coster. The displacements are quite consistent with those reported by Zumstein for tungsten. The experimental values for the M_3 and M_4 discontinuities lie between the two sets of computed values for those levels. While the experimental values for M_5 are slightly lower than the computed ones, yet the deviation from those values is comparable to that of M_3 and M_4. Two types of absorption discontinuities were found on the spectrograms—"white line" absorption and "limits" separating regions of unequal darkening. No evidence was found of a component on the short wave-length side of M_3 as was reported by Zumstein for tungsten.

SATURDAY AFTERNOON AT 2 O'CLOCK

Room 32

43. Collisions of the second kind between zinc and mercury atoms. J. G. WINANS, University of Wisconsin.—The preliminary results are described in Nature **118,** 46 (1926). Additional evidence has been obtained that mercury atoms in the $2P$ state are effective in collisions of the second kind with zinc atoms. The quartz tube containing zinc and mercury vapors was illuminated by nearly monochromatic light of λ1849 ($1S-2P$) obtained by a focal isolation method from a hot mercury arc. The zinc sharp triplet ($2p_{1,2,3}-2s$) appeared very clearly in the secondary radiation and failed to appear when all wave-lengths shorter than 2100 were absorbed from the exciting light by a sheet of very thin glass. Similar results were obtained using the water cooled mercury arc and the aluminum spark as light sources. λ1849 has been photographed through an air path of 90 cms. The zinc lines which appear when various light filters (chlorine, glass, and acetic acid) are placed in the path of the exciting light from a mercury arc, give evidence that some mercury atoms in the $3d$ state transfer their entire energy to zinc atoms in collisions of the second kind. A calculation on the basis of the kinetic theory shows that, under the conditions of this experiment, an excited mercury atom with an associated metastable state is probably about twice as effective in producing collisions of the second kind as one with no metastable state near it.

44. The resonance glow in a hydrogen discharge tube. ROGERS D. RUSK, North-Western College.—At pressures of hydrogen below 0.2 mm and potentials higher than the minimum arcing potential a blue haze extends throughout the hot filament discharge tube. Systematic variations of gas pressure, discharge potential, filament current and anode distance have been made to determine the nature of the glow, which corresponds to the type-three discharge mentioned by Richardson and Tanaka (Roy. Soc. Proc. **106** A, 640, (1924)). For a fixed anode distance the appearance of the glow occurred at a constant potential for pressures below 0.2 mm at which pressure it became indistinguishable from the more common arc type of the glow. The intensity of the glow and its extent are functions of gas pressure, anode distance and potential. Weakness of the Balmer lines and the effect of pressure change suggest a close relationship between the life of the excited molecule and its collision frequency.

45. The distribution of energy among electrons rebounding from helium atoms. A. L. HUGHES and L. W. JONES, Washington University.—A narrow beam of electrons of known velocity was directed into helium at various pressures below .01 mm. A pair of slits selected those electrons rebounding at 90 degrees ± 3 degrees, and their distribution of velocities was measured by the magnetic field method. The pressure used was sufficiently low to insure that the rebounding electrons had made but one collision. For electrons having energies ranging from 16 to 100 volts, it was found that the rebounding electrons had exactly the same energy as they had before collision. In particular, it was noted that there were no electrons rebounding at 90 degrees with a loss of energy corresponding to excitation (20 volts) or to ionization (25 volts).

46. Secondary electron emission from molybdenum. ALBERT W. HULL and J. M. HYATT, General Electric Co.—A special three-electrode tube was used, consisting of a short straight tungsten filament in the axis of a long cylindrical molybdenum grid and plate. The tube was thoroughly exhausted, a small amount of caesium introduced, the tube sealed off from the pump, and the plate bombarded by caesium positive ions at 600 volts for five hours. The tube was then immersed in liquid air and the plate heated by induction until the plate current showed no change with continued heating. Measurements of plate current were made, as a function of grid and plate voltage, from zero to 2000 volts. The fraction of the primary electrons which reached the plate was determined by removing the tube from liquid air, reversing the potentials, and measuring the positive ion currents from the filament to grid and plate. The number of secondary electrons per primary electron was thus calculated and found to increase from 0.45 at 20 volts to a maximum of 1.23 at 900 volts, decreasing to 1.04 at 2000 volts. These values were reproducible within 2% at different times and in different tubes.

47. Secondary electron emission produced by positive caesium ions. J. M. HYATT, Research Laboratory of the General Electric Company and Union College.—The source of the positive ions, a short tungsten filament maintained at about 1200°K in the presence of caesium vapor, was mounted on the axis of a long cylindrical molybdenum grid and plate. A potential of -600 volts was applied to the grid and potentials from $+50$ to -650 were applied to the plate. While the plate was between $+50$ and 0 only secondary electrons from the caesium covered grid reached it. When the plate potential was made negative it caught positive ions in addition to the secondary electrons. The plate current became constant at -50 volts and remained so until the plate potential reached that of the grid. At this point the plate current suddenly increased 4% due to the emission of secondary electrons from the plate. Further increase of the positive ion velocities was accompanied by a uniform increase of the secondary electron emission. Similar observations were made with the grid maintained at six lower potentials. Determinations made of the secondary electron emission from both grid and plate were in agreement and showed that the number of secondary electrons per positive ion striking the caesium covered surfaces increased uniformly from .02 at 200 volts to .11 at 600 volts.

48. The effect of an electric field on a radiating hydrogen atom. K. L. HERTEL, University of Chicago. (Introduced by A. J. Dempster.)—In a previous paper experiments were described in which hydrogen canal rays were allowed to pass into a very high vacuum, so that the natural decay of radiation could be observed and the changes in polarization produced by a transverse electric field during the radiation process. The experiments have been continued under improved conditions with various fields, and various velocities of the rays. In all cases the original polarization is suddenly reversed as soon as the field is applied so that the electrical component parallel to the field becomes stronger. This change in polarization must take place in less than 2×10^{-9} seconds. In the uniform field the polarization of the radiation decreases gradually to zero or even reverses slightly. Measurements were made with three different velocities of the rays and showed that the time required for this gradual return of the polarization is about 4×10^{-8} seconds. Photographs were also made of the rays on emerging from the condenser. Here again there was an increase in the polarization of the light emitted the component parallel to the field again becoming stronger. This took place in the stray field at the end of the condenser and occurred farther out with strong fields than with weak.

49. Polarization of λ2537 of mercury. H. F. OLSON, University of Iowa.—$1s-2p_2$ of mercury excited by plane polarized light shows 79% polarization both in the absence of any magnetic field and in the presence of a field parallel to the electric vector in agreement with recent results of Keussler. That such a field should produce no change in the polarization is in accord with Heisenberg's extension of the principle of spectroscopic stability. That the polarization is not complete might be interpreted as due to collisions but more probably is due to the fact that in very weak fields some of the fine components of 2537 have not the same Zeeman pattern as in strong fields. The polarization with other relative orientations of field and light vector and the variation of polarization with field intensity in weak fields may be interpreted successfully by means of a semi-classical model, with proper relative intensities parallel and perpendicular to the light vector, rotating after excitation with an angular velocity $\frac{1}{2}g(e/m)\ (H/C)$ and emitting a damped wave. From curves connecting depolarization, rotation of maximum of polarization, etc., with field intensity κ has been found to be $1.02(\pm.02)\ 10^7\ \text{sec}^{-1}$.

50. Polarization of light excited by electron impact. JOHN A. ELDRIDGE, ALEXANDER ELLETT, and HARRY F. OLSON, University of Iowa.—Ellett, Foote and Mohler and also Skinner have observed the polarization of the mercury spectrum when excited by a well defined stream of slow moving electrons. The present experiment shows that the lines of the sharp subordinate series are in general weakly polarized; but those of the diffuse subordinate series quite strongly polarized (in agreement with Skinner). In this series the electric vector of the excited light is normal to the electron stream whenever $j=0$ and parallel to the stream for lines involving a decrease of j. In the cases in which j increases the line is less strongly polarized and our results are not definite. As has been previously suggested we suppose the excited atoms with their j vector in or near the plane normal to the electron stream. Qualitatively the results for this series are in agreement with the concept (Rubinowicz) that the atom emits a plane polarized or circularly polarized light quanta according as j remains constant or changes by one. This simple theory for the polarization can not be correct, however, as it leads to parallel polarization never greater than 33%, as contrasted with 60% which has been found for some lines; it also falls down when applied to the somewhat weaker polarization of the other series.

51. Impact polarization and the spinning electron. A. ELLETT, University of Iowa.—The principle of conservation of angular momentum together with Heisenberg's extension of the principle of spectroscopic stability lead Foote, Mohler and the writer to predict for λ2537 of mercury polarization with major electric vibration parallel to the exciting electron beam, contrary to fact. Eldridge, Olson and the writer have shown that

in most cases lines of the mercury spectrum for which ΔR during the collision is ± 1 exhibit polarization of the type to be expected if the Zeeman levels for which $m = \pm 1$ are favored in excitation, whereas if ΔR in excitation is zero the assumption that the level $m = 0$ is favored leads to the correct conclusion. On the spinning electron hypothesis these results may be interpreted by saying that when R changes the spinning electron turns over during the collision and gives to the atom a unit of angular momentum parallel to the electron beam, and to the magnetic field which may be applied in this direction without changing the resulting polarization. Likewise $1s - 2p_1$ of sodium should show zero polarization and $2p_2 - 3d_2$ of thallium should show polarization, if the reorientation of the spinning valence electron relative to the orbital momentum is brought about by the colliding electron turning over. If this is not true, the latter should behave like D_2 of sodium.

52. Dependance of the free path of potassium ions in various gases on their velocity F. M. DURBIN, University of Chicago. (Introduced by A. J. Dempster.)—Potassium ions from a hot anode were accelerated through potential differences varying from 9 to 350 volts between an anode and a slit. The beam passing through the slit was bent into a semicircular path by a magnetic field so as to fall on a second slit. The number passing through this distance of 11 cm without neutralization or scattering out of the beam was observed by an electrometer with different gas pressures in the chamber. Keeping the current to the first slit constant, the intensity of the rays decreased exponentially as the pressure was increased. The mean free path may be deduced and a comparison with the kinetic theory free path gives the number of collisions made by the ions before being lost from the beam. In helium this number varied from 10 at 250 volts to 2.34 at 8.5 volts. Air, hydrogen, nitrogen, helium, oxygen and argon were studied, and in all cases the curves giving the dependance of the free path on the velocity showed an approach to a constant high value of the free path at the higher velocities, and a more or less rapid decrease to a value approximating the kinetic theory value at the lowest speeds.

53. Electrical properties and nature of active nitrogen. PHILIP A. CONSTANTINIDES, University of Chicago. (Introduced by A. J. Dempster.)—Glowing active nitrogen was drawn in succession through two sets of electrodes each consisting of two concentric cylinders. The ionization current in the second electrode remained constant despite the variation from 0 to 250 volts cm in the field of the first electrode. This indicates that the ionization is produced by changes taking place after the passage of active nitrogen through the first electrode. Using electrodes of various areas, the negative charges were found to be proportional to the areas of the negative electrodes, which shows that the conductivity is due to photo-electrons emitted from the electrodes. The effect of various gases on the duration of afterglow has been examined, the most important result being that it is not affected by helium even when the helium is made ten times the density of the nitrogen. It was found that hydrogen and mercury molecules are not ionized by collisions with active nitrogen molecules, while indications are that iodine molecules are ionized. This suggests that the phenomena associated with active nitrogen may be due to a metastable state of the nitrogen molecule with energy between 9.4 and 10.4 volts.

54. On the nature of gaseous ions. HENRY A. ERIKSON, University of Minnesota.—When ionizing rays are passed through oxygen, nitrogen, hydrogen, carbon dioxide and argon, a positive ion and a negative ion are formed. These have all initially the same mobility in air. The value of this mobility in moderately dry air is 1.87 cm/sec per volt/cm. In a fraction of a second the initial positive ion changes into a final ion which has a mobility of 1.36. The negatives undergo no change. No greater mobility in air than 1.87 is observed. The value 1.87 is the mobility of the simplest singly charged body present.

The lack of dissociation, the known nature of the ionizing process, the results in the case of argon, the possible separation of the two groups of ions and the like mobility of the initial ions as well as the final ions, leads to the conclusion that an electron escapes from the molecule due to the action of the ionizing agent. The initial positive ion is thus formed. The electron set free soon attaches itself to a neutral molecule thus forming the negative ion. These are the two 1.87 bodies. The positive 1.87 body soon shares an electron with a neutral molecule thus forming the 1.36 two molecule body. The value 1.87 is thus a characteristic of a one-molecule ion and 1.36 a characteristic of a two-molecule ion.

SUPPLEMENTARY PROGRAM

When two or more papers are offered by the same member, one only of these will be assigned a place on the regular program, while the others will be placed in a supplementary program, to be called for if time permits.

Papers received after the program has been printed will be placed in the supplementary program.

The papers in the supplementary program may be called for at any session in Room 32 after the completion of the regular program for the session.

55. A new electrophoresis cell. MELVIN MOONEY, National Research Fellow, University of Chicago.—Endosmotic streaming along the walls of an electrophoresis cell is compensated by reverse streaming along the axis. To eliminate the resulting velocity gradient in the water, a new cell was designed consisting essentially of a complete loop or hydrodynamic circuit. The lower half of the loop is a long 0.7 mm capillary tube, with thin walls to permit microscopic observation of the colloidal particles within. The upper half, filled with distilled water, is a short 12 mm tube and therefore has a very small hydrodynamic resistance. Consequently the water moves through the capillary with uniform velocity over its cross-section, the compensating reverse flow taking place through the large tube. The advantages are: (1) the correction applied to the observed velocity of a colloidal particle to obtain its velocity with respect to the water is no longer subject to errors in locating the particle in the tube: (2) the endosmotic velocity of the water is generally opposite and approximately equal to the electrophoretic velocity. Consequently the arrangement is suitable for precise measurement of differences in mobility of different particles or of the same particle under different fields.

56. Critical potentials of the spark lines of mercury. JOHN A. ELDRIDGE, University of Iowa.—Block has classified as belonging to three groups 300 spark lines of mercury and Dejardin has found three threshold values for the exciting potentials. However the number of lines studied by Dejardin was small and it might be questioned whether all of the known spark lines did actually fall into these three groups. The intensities of 30 of the stronger spark lines have been measured as a function of voltage and three critical values found less than 150 volts, at 18, 24 and 57 volts respectively. The absolute values of such critical potentials is not certain as the values may be altered several volts by changing the current density.